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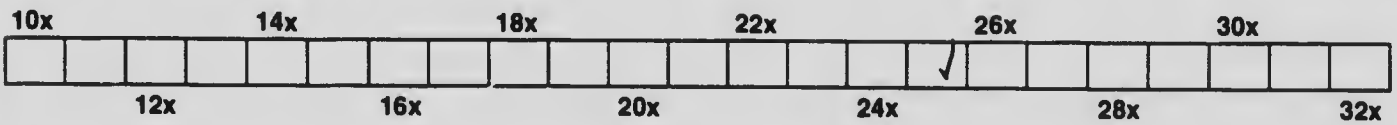

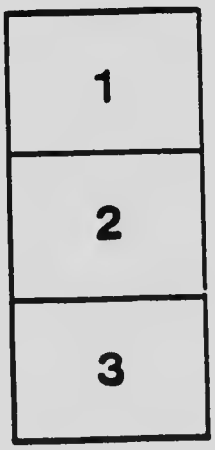

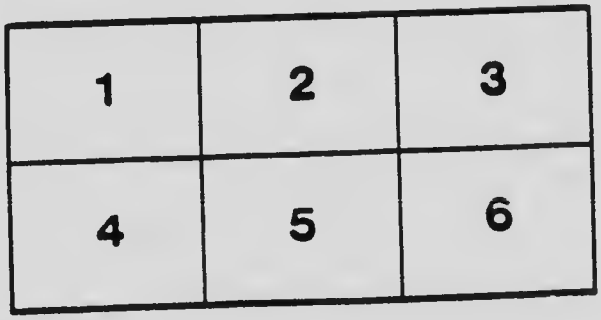

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NOTES ON THE GEOLOGY AND PALÆONTOLOGY OF THE LOWER SASKATCHEWAN RIVER VALLEY

by

E. M. Kindle

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Notes on the Geology and Palæontology of the Lower Saskatchewan River Valley.

By E. M. KINDLE.

INTRODUCTION.

The observations recorded here are the result of field work undertaken during the summer of 1913 for the purpose of extending northward and westward the stratigraphic and faunal studies begun the preceding season about the shores of Lakes Winnipegosis and Manitoba. The completion of the new Hudson Bay railway to Pas on the Saskatchewan and the laying of steel some 40 miles farther had made easily accessible for the geologist a strip of country along its line about 130 miles in length. This line traverses the region at about right angles to the strike of the rocks. In an unsettled, forest-covered region like this where geological data could be obtained heretofore only along canoe routes, it was expected that the rock exposures resulting from railway construction might furnish new information of value. The trip was continued down the Saskatchewan by canoe to Grand Rapids at the mouth of the river, thence by sailboat around the north end of Lake Winnipeg to Warren Landing at the head of Nelson river. Between the latter point and Selkirk, steamer service is maintained throughout the navigation season. Warren Landing lies in the Archæan area just east of the eastern border of the Palæozoic rocks, while Hudson Bay Junction, the starting point of the new railway, lies southwest of the Palæozoic belt, in a Cretaceous area. The route traversed, therefore, crosses the

whole Palæozoic belt from 50 to 100 miles north and west of the sections described in my last summary report.[1]

TOPOGRAPHY AND DRAINAGE.

The topographic features of northern Manitoba are the product of a series of degradational factors which have been successively dominant in moulding the relief of the region. The present topography is the joint product of a long period of preglacial erosion, succeeded by the work of the great ice sheet, which in turn has been modified by extensive deposition of lacustrine and fluvial sediments. The position and relative height of the larger features of relief were determined by a long cycle of erosion preceding the glacial epoch. During this early stage of topographic development the dip and strike and relative hardness of the several rock formations were the chief controlling elements in directing the maximum effects of erosion. Under the influence of a gentle westerly dip the edges of the different groups of strata retreated westward at different rates. The northwesterly and southwesterly trending scarps which were developed at this period correspond in direction with the general direction of the strike of the rocks.

By far the most conspicuous and important topographic feature developed at this time is the Cretaceous escarpment marking the eastern front of an elevated plateau known from south to north under the several names of Duck mountain, Porcupine mountain, and Pasquia hills. The eastern face of this escarpment rises sometimes abruptly but more often by a series of foothills and terraces to a height of nearly a thousand feet above the broad plain occupied to the east and north by the basins of Lake Winnipeg, Winnipegosis, Cedar, and many smaller lakes connected with the lower valley of the Saskatchewan river.

Another, but less conspicuous, escarpment separates the Winnipeg basin from that of the other two lakes mentioned above. This scarp marks the eastern limit of the Silurian limestone. It is well developed on the north and rises somewhat more than 100 feet above Lake Winnipeg in the vicinity of the Saskatche-

[1] Sum. Rept., Geol. Surv. Br., Dept. of Mines, for 1912, pp. 404-406.

wan river. The Grand rapids of the Saskatchewan are formed by the river crossing this scarp which is a prominent physiographic feature lying a few miles back from the lake shore, where it maintains a northerly trend for 50 miles or more north of the Grand rapids. South of the Saskatchewan this scarp becomes a less conspicuous feature. The summit of the scarp affords the most promising route in the Saskatchewan district for a wagon road between Grand Rapids and Gypsumville which is the present terminus of the Canadian Northern line traversing the region east of Lake Manitoba.

Prominent cliffs have been developed in the Devonian limestone series in the northern part of the Lake Winnipegosis basin, rising sometimes 80 feet above the lake, but none of these have any considerable extension north and south.

Since the early stages of the glacial epoch geologic processes in this region have acted chiefly in a constructive way, first through the deposition in the river valleys of vast quantities of glacial till, followed by the lake deposits of Lake Agassiz, and still later by the deposits of the relatively small successors of Lake Agassiz and by the waters of the Saskatchewan river. The blocking of the original lines of drainage, which were adjusted to the Winnipeg and Winnipegosis plains, by the drift of the Glacial period, left visible only some of the more conspicuous features of the original topography already mentioned. Over the glacial drift a mantle of lacustrine deposits, generally thin but sometimes heavy, was spread by the great sheet of water known as Lake Agassiz. This lake, shortly after the retreat of the ice, covered the country from the Cretaceous scarp west of Lake Winnipegosis to the hills of crystalline rock east of Lake Winnipeg and extended from Minnesota and South Dakota nearly to the Churchill river.[1] The gravel terraces marking the old shore-lines, spits, and bars of the various levels of this ancient lake form conspicuous topographic features locally. Tyrrell found the highest of these, on Duck mountain, to have a height

[1] Warren Upham, Geol. Surv., Can., Ann. Rep. 1888-89 (1890), Vol. IV, pt. E. pp. 1-156.
Tyrrell, J. B., Geol. Surv., Can., Ann. Rep. 1890-91 (1893) Vol. V, pt. E, pp. 1-235.
Geol. Surv., Can., Ann. Rep. Vol. XIII, pt. F.
Dowling, Geol. Surv., Can., Ann. Rep. Vol. XIII, pt. FF.
McInnes, Wm., Geol. Surv., Can., Mem. No. 30, 1913, pp. 125-127.

of 537 feet above Lake Winnipegosis. One of these old gravel bars is exposed at Grand rapids in the Saskatchewan river just west of the old cut-off channel. This bar or beach lies about 80 feet above the river and follows the high ridge northward an undetermined distance. South of Pas another of these old beaches composed of limestone gravel is seen along the railway. It lies upon the morainal ridge of glacial till across which the river cuts at Pas. One of these old gravel beaches is crossed by the Hudson Bay railway just south of Westray.

The present drainage system is superposed on the old bed of Lake Agassiz. The numberless lakes which represent the last stage in the disappearance of the waters of this ancient lake are generally connected either permanently or temporarily with the Saskatchewan through which their outflow reaches Lake Winnipeg. In time of high water, some of these lakes act as temporary receivers of the surplus water of the river. The load of silt carried by the strong current of the river from its upper reaches, finds in these broad, shallow lakes the still-water conditions necessary for the deposition which will eventually lead to their total extinction. In the case of the small lakes of the Saskatchewan valley the accumulation of the remains of plants is the most important of the agencies which add to their deposits and lead to their ultimate filling. A number of plants which thrive best in water contribute to this result by adding each season their remains to the accumulating mass at the bottom of the lake. Some of these, like the rushes which are so universal a feature in the muddy shallows of most of the lakes, flourish in water 6 to 8 feet deep. The most conspicuous and abundant of these is the rush *Phragmites communis*, growing 12 to 18 feet high and thriving best in water 4 to 6 feet deep. This plant always joins the advance guard of the water plants and for miles along the lower part of the Saskatchewan forms an almost impenetrable wall, making approach to the shore often impossible for a considerable distance.

The Saskatchewan river has some interesting features in the lower part of its course between Pas and Cedar lake. Throughout the 100 miles of this part of the course it flows across a flat country, its channel cut in the old lake clays of Lake Agassiz.

The banks are very low, seldom rising more than 4 or 5 feet above high water. The maximum rise of the river in time of flood above low water stage is reported to be only about 3 feet, by the Hudson's Bay Company's agent at Cedar lake. The slight effect which floods have on the level of the lower river is due to the fact that any excess of water is taken up by the large lateral lakes connected with the river.

It would be possible by lowering, a few feet, the discharge channel of Cedar lake in the vicinity of the rapids by which the lake waters pass into the lower river to drain a vast area of marsh land along the lower part of the river above Cedar lake. When unoccupied land becomes sufficiently scarce in the northwest the engineering problems involved in such an undertaking will no doubt receive careful consideration.

From Lake Winnipeg the Saskatchewan drainage passes through the Nelson river to Hudson bay.

AREAL DISTRIBUTION OF SILURIAN DOLOMITE.

In the region of the large Manitoba lakes the Silurian and Devonian rocks lie so nearly horizontal that neither strike nor dip can ordinarily be determined from individual exposures. The combined areal work of several geologists, however, has shown that in the territory west of Lake Winnipeg the Palæozoic rocks for 250 miles or more strike 20 to 25 degrees west of north and dip to the southwest away from the Laurentian rocks at a few feet per mile. This northwesterly strike swings abruptly to the west not far from the north end of Lake Winnipeg. This change in strike is accompanied by the overlap of Cretaceous beds upon the Devonian and Silurian to the north of Red Deer river. The westerly and northwesterly strike of the Silurian rocks in the Saskatchewan River valley probably differs little from the general trend of the river between Pas and Grand Rapids; consequently the entire 150 miles of river and lake shore intervening between the mouth of the river and Pas are within the areal limits of the Silurian limestones. Owing to the very deep filling by glacial, lake, and river deposits along the Saskatchewan valley between Pas and Cedar lake no outcrops of bed-rock ap-

pear for more than 50 miles below Pas. At the Cedar Lake mouth of the river, however, numerous low cliffs of limestone are exposed along the banks of the river and along the sides of the islands at its mouth. The south shore of Cedar lake is low and swampy until the east end is approached; where numerous small rocky islands and ledges of limestone occur. These limestone ledges outcrop at frequent intervals and give rise to four rapids above Grand rapids. Between the Roche Rouge and Grand rapids the river flows for a short distance between high banks of glacial till before cutting across the scarp of Silurian rocks near its mouth.

The outcrops examined in the Saskatchewan valley thus fall into four groups if areally considered. The most westerly of these is exposed in the cuts of the Hudson Bay railway from 4 to 25 miles northeast of Pas. The other three lie respectively in the Cedar Lake estuary of the river, about the eastern shore of Cedar lake, and along the lower part of the river between Cross lake and the foot of Grand rapids.

STRATIGRAPHY AND FAUNAS.

The rock exposures at Grand rapids afford the best section of the Silurian which is known in Manitoba. Near the head of the rapids at the narrowest part of the channel the River cliffs of Silurian dolomite rise about 30 feet high on either side of the river. Beds somewhat lower than the base of these cliffs are exposed a short distance above the head of the old overflow or cut-off channel. Beds about 40 feet higher than the top of the River cliffs are exposed near the old tramway. A section combining the beds exposed in the lower and upper part of the Rapids together with those near the tramway is shown following.

Grand Rapids Section.

		Thickness feet.
(i)	Hard light grey irregularly bedded dolomite (summit near tramway)	2
(h)	Buff dolomite (in tramway cuts) and covered	35±
(g)	Grey to pale buff thin-bedded, fine-textured dolomite, moderately hard and evenly bedded weathering to innumerable small rectangular blocks. These beds are cut by joints 4 to 10 feet apart into rectangular pillars. Fossils scarce	22
(f)	Hard light buff dolomite with coarse texture and much more numerous fossils than beds above. Ostracodes, Stromatoporoid and Favosite corals common	4
(e)	Covered	10±
(d)	Light buff dolomite with *Conchidium decussatus* very abundant[1]	3
(c)	Whitish thin-bedded barren dolomite	8
(b)	Hard compact bluff limestone	1
(a)	Brecciated limestone	2

The basal beds of this section are supposed to represent a horizon near the base of the Silurian as represented in this region, but the actual contact of the Silurian and Ordovician beds has not been observed in this district. The nearest exposures of Ordovician beds, which are known, occur 15 miles northeast of Grand Rapids on the shore of Lake Winnipeg south of Sturgeon Gill river. Cliffs of drab-coloured magnesian limestone 10 to 40 feet high face the lake in that vicinity. The shore intervening between these cliffs and the base of the section at Grand Rapids is low and composed of glacial till and limestone shingle and pebbles derived from it. Just what thickness of beds may be between the top of the cliffs at Sturgeon Gill and the base of the Grand Rapids section it is impossible to state, but the relative position of the two sections with respect to the general strike of the rocks leads to the opinion that it is not very great. Whatever this unobserved interval may include, the earliest Silurian fauna at present known in the district is the *Conchidium decussatum* fauna which occurs near the base of the Grand Rapids section in bed d. This large Conchidium occurs in great profusion in the thin bed to which it seems to be confined near the base of the section. Close examination of most of the outcrops on the north side of the river at Grand Rapids failed to detect

[1] This bed outcrops on the south side of the river according to Tyrrell (Ann. Rep. Can. Geol. Surv., Vol. V, 1890-91 (1893) p. 147E) This and the beds a, b, and c were not seen by the writer.

any trace of this fossil in beds higher than those from which Tyrrell originally reported it. Loose slabs of the dolomite from this bed, which are crowded with *C. decussatus*, may be found in the drift throughout the Grand Rapids district. It is particularly abundant in large, loose slabs in the bed of the stream flowing out of the old cut-off channel. Other specimens, evidently transported by glacial action, were observed on the high ridge west of Grand Rapids village. These slabs suggest a northerly extension of this bed in which *C. decussatus* is as abundant as it is in the river section. *C. decussatu* greatly predominates in the number of individuals over all the associated species combined. Other species are in fact scarce in this bed. The following species have been recognized in this fauna:

Sponge spicules.
Favosites niagarensis Hall.
Halysites catenulatus L.[1]
Alveolites niagarensis Rominger.[1]
Lyellia papillata Rominger.[1]
Stropheodonta sp.
Orthis cf. *flabellites* Foerste.
Conchidium decussatum Whiteaves.
Euomphalus sp.[1]
Diaphrostoma sp.
Trochonema sp.

Bed (f) of the section is the lowest accessible bed near the head of the rapids. Fossils are common in this bed but not easily obtainable in a determinable condition. The collection from bed (f) includes:

Stromatopora sp.
Favosites sp.
Zaphrentis sp.
Meristina? sp.
Stropheodonta sp.

[1] Species recorded from this bed by Tyrrell, Geol. Surv., Can., Ann. Rep. Vol. V, p. 147E, (1893) not collected by the writer.

The thin-bedded dolomites of the next higher division (g) contain very few fossils at most levels. Certain strata, however, hold an abundance of the shells of a small lamellibranch and the ostracodes indicated in the following list:

Pterinea occidentalis Whiteaves.
Phanerotrema cf. occidens (Hall).
Gomphoceras sp.
Gomphoceras parvulum Whiteaves.
Isochilina grandis var. *latimarginata* Jones.
Leperditia hisingeri Jones.
Leperditia hisingeri var. *egena* Jones.
Leperditia hisingeri var. *caeca* Jones.

In the higher beds of the section, fossils which are determinable are scarce. One or more species of *Stromatopora* and *Favosites* are met with. The type material of the coral *Petraia* (*Pygmaea?* var) *occidentalis* Whiteaves and *Lyellia affinis* Billings, appear to have been derived from these upper beds. Tyrrell[1] also records from them *Stropheodonta acanthoptera.*

Close comparison between the faunas of the Grand Rapids section and those of eastern Silurian sections owing to dearth of common species is difficult. The dominance in the lowest fauna of the section of such a genus as *Conchidium*, however, makes it probable that the base of this section represents a Silurian horizon not earlier than Clinton and probably of early Niagara age. It appears to represent a portion of the Stonewall limestone[2] of south central Manitoba.

Above Grand rapids the river flows for a short distance between cut banks of boulder clay which are 60 feet high in places. About 2½ miles above the end of the Grand Rapids tramway the dolomites are again exposed in flat-lying beds at Roche Rouge rapids. These exposures, together with others at a third rapid just below Cross lake, represent the higher beds of Grand Rapids section. On the west side of Cross lake, ledges of dolomite 4 to 6 feet high are exposed on Burnt island and on

[1] Ibid.
[2] Geol. Surv., Can., Sum. Rept. 1912, p. 248.

the opposite shore. West of Demi-charge rapids, the dolomite is well exposed along the south shore of the broad expansion of the river. These rise 35 to 40 feet above the river in places. Small caves are seen at some points opening a little above the water. Sink holes of rather small size connect with some of these. Fossils are rather scarce in these dolomites. A considerable collection made on a bluff 2 miles west of Demi-charge rapids, together with others from the eastern shore of Cedar lake, was lost in a canoe accident. Low cliffs of light grey dolomite 5 to 25 feet high in horizontal beds occur at frequent intervals along the southeast shore of Cedar lake as far west as Collins island. The most westerly of these exposures is located about 5 miles southwest of Collins island. None of the many exposures observed about the east end of Cedar lake suggest any deviation from horizontality to the eye, but it is probable that a gentle southwesterly dip of a few feet to the mile prevails throughout the district. If this inference, which is based on the demonstrated higher position stratigraphically of successive exposures of the limestones about the northern shores of Lake Winnipegosis, is correct, the dolomites in the vicinity of Collins island are higher in the section than the topmost beds of the Grand Rapids section.

Along the south side of Cedar lake, west of Collins island, the shore for 20 miles or more is very low and no outcrops of bedrock were observed. Occasional loose slabs were seen along this shore with an abundance of *Strophеodonta acanthopteria*. It appears probable that the horizon of the Gypsumville gypsum lies near the surface along some parts of this low-lying south shore to the west of Collins island.

At the western end of Cedar lake the Silurian dolomite outcrops in some of the small islands which lie not far off the mouth of the Saskatchewan river. Other good exposures of the rock occur in a low bluff about 6 or 8 feet high near Chemahawin, the Hudson's Bay Company's post near the mouth of the river. A collection of fossils was made from a rocky point about 2 miles west of Chemahawin. About 5 feet of flat-lying, hard, buff-coloured dolomite at this locality afforded the following species:

Sponge (genus indeterminate).
Halysites catenularia Hall.
Favosites niagarensis Hall.
Cystiphyllum cf. niagarense (Hall).
Orthis flabellites Foerste.
Stropheodonta acanthopteria Whiteaves.
Leptaena cf. rhomboidalis (Wilckens)
Leptaena sp.
Leptaena parvula n.sp.
Barandella ventricosa Hall.
Camarotoechia cf. *eckwanensis* Whiteaves.
Trematospira sp.
Homeospira cf. *apriniformis* (Hall).
Ilaenus? (fragment).

This fauna also represents, the writer believes, a horizon of late Silurian age corresponding to that of the grey dolomites which outcrop in the jack-pine ridge, 8 miles southwest of Gypsumville and near the end of the old Gypsumville tramway near the shore of Lake Manitoba. The occurrence in the faunas of both localities of a peculiar new species, *Leptaena parvula*, which has not been seen in the lower beds of the Saskatchewan section, supports this opinion. These higher beds belong to the *Leperditia hisingeri* zone of the Stonewall limestone.[1]

With the exception of a small exposure of grey dolomite in the west bank of the river near some Indian cabins about 15 miles above Chemahawin, the outcrops which furnished the fauna listed above are the last seen below Pas in ascending the river from Cedar lake.

Northeast of Pas, the Hudson Bay railway traverses a region in which east of Reed, Clear, and Cormorant lakes, the Silurian dolomite generally lies at or near the surface. The general surface of the country east of Clear lake stands 50 feet or more above the lake, thus giving good drainage and freedom from the swampy conditions which prevail along considerable stretches of the road southwest of Pas. The dolomite is exposed at frequent intervals in cuts along the railway. The exposure

[1] Geol. Surv., Can., Sum. Rept. for 1912, pp. 248-250.

nearest Pas is about 4 miles from town. In this and succeeding cuts to the northeast the dolomite is exposed in sections 2 to 5 feet thick. The rock is a light grey to lemon yellow coloured dolomite, lying in horizontal beds. The dolomite is generally a hard vesicular rock in which the moulds of salt crystals are occasionally seen. Fossils are generally scarce and at some localities none were found. The exposures in a cut about 23 miles northeast of Pas, in connexion with the natural outcrops on the east rim of the lake a mile northwest of the cut, give a vertical section of about 40 feet of grey to buff dolomites. Fossils were collected from the very refractory dolomite exposed along the railway at this point. A stromatoporoid coral and in certain strata ostracods are abundant at this locality. Other fossils are scarce and poorly preserved. The following list indicates the character of the fauna as represented here.

Stromatopora cf. *concentrica* Hall.
Favosites cf. *niagarensis* Hall.
Stropheodonta sp.
Orthothetes sp.
Camarotoechia cf. *winiskensis* Whiteaves.
Pterinea cf. *occidentalis* Whiteaves.
Diaphrostoma sp.
Holopea sp.
Murchisonia? sp.
Orthoceras sp.
Gomphoceras sp.
Cyrtoceras sp.
Leperditia cf. *hisingeri* Jones.

The fragmentary character of most of the fossils represented in the above list discourages close comparison with the other faunas obtained from this region. The fauna is believed to represent a horizon in the lower part of the Silurian.

DESCRIPTION OF SPECIES.

Leptaena sinuosus n. sp.

Plate 1, Figures 1-4.

Shell small, subquadrate, cardinal extremities produced. Surface of shell covered with transverse irregularly zigzag wrinkles giving a surface comparable with that of a shrivelled apple. Toward the cardinal extremities these wrinkles take on a semblance of regularity and appear in a limited area as transverse folds. The surface of each valve is marked by about 8 or 10 widely spaced slender but sharply defined striæ. About half of these originate at the beaks, the remainder arising in the median part of the shell and extending thence to the front. The flat intermediate spaces between these striæ in perfectly preserved specimens are occupied by extremely fine striæ, but on the dolomitic material representing the collection they are seldom clearly preserved. Margin of valves geniculated in front and but slightly or not at all on lateral margins, thus giving a sinuous antero-lateral margin with a sinus-like effect at the front of the valves. This geniculation in the median portion of the anterior margin of the valves is shown in figures 1 and 4.

The ventral valve is gently convex with a well marked subcircular muscular scar sharply defined at the sides near the hinge line by slightly curved dental lamellæ, but shallow and indistinctly defined in front. Anterior margin of valve abruptly bent downward producing a sinus-like depression at the front.

Dorsal valve nearly flat with a geniculated anterior median margin. Short, widely diverging teeth extend forward from the cardinal area. The character of the geniculated margin which is recurved only near the middle of the anterior margin distinguished this shell from *L. parvula* which is geniculated around the entire margin. The peculiar surface markings and small size distinguish both this species and *L. parvula* from other species of this genus.

The types are from the dolomitic limestone outcropping at the east end of Cedar lake 2 miles above Cedar Lake P.O. (Chemahawin), Manitoba.

Leptaena parvula n.sp.

Plate I, Figures 5-9.

Shell small, outline as shown in figures 5 to 9. Surface of shell irregularly wrinkled throughout. The surface of each valve is marked by about eight or more widely spaced slender but sharply defined striæ, which are well defined only in the anterior half of the shell. Extremely fine striæ occupy the intermediate spaces between these striæ, the coarser striæ being separated by groups of six or eight fine ones. Margin of valves moderately geniculated. The geniculation though not very pronounced appears to be approximately uniform on the anterior and lateral margins.

A well marked sub-circular muscular scar sharply defined at the sides by slightly curved dental lamellæ, but shallow and indistinctly defined in front, characterizes the interior of the ventral valve.

Dorsal valve nearly flat with a narrow geniculated margin. Cardinal process divided into two small, diverging arms. A low, narrow ridge extends forward from the base of the cardinal process between the shallow, muscular impressions about one-sixth of the distance across the valve. In some specimens this ridge is almost or quite obsolete. Short, lateral lamellæ extend forward from the hinge line making acute angles with it.

Horizon and Locality.—The types are from the dolomitic limestone outcropping 8 miles west of Gypsumville. Other specimens of this shell which are here figured, have been found in the dolomite at the east end of Cedar lake, 2 miles above Cedar Lake P.O. (Chemahawin), Manitoba.

Both occurrences represent the upper part of the Stonewall limestone. It is unknown in the lower part of the Saskatchewan River section.

Conchidium decussatum (Whiteaves).

Plate II, Figures 1-6; Plate III, Figures 1-6; Plate IV, Figures 1-4.

Pentamerus decussatus Whiteaves, Canadian Record of Science, 1891, p. 295, pl. 3, figs. 3, 4.—Calvin, Bull. Lab. Nat. Hist. State Univ. Iowa, II, 1892, p. 164, pl. 11, figs. 1-3; pl. 12, fig. 2.

Conchidium decussatum Hall and Clarke, Pal. New York, VIII, Pt. II, 1893, p. 235, pl. 65, figs. 1, 2; pl. 66, fig. 15.

Conchidium decussatum Whiteaves, Geol. Surv. of Can. Palæozoic Fossils, Vol. III, P[illegible]v, 1906, pp. 293-295, pl. 26, figs. 1-2.

Conchidium decussatum Kindle, Geol. Surv. of Can., Summ. Rept. 1912 (1914) p. 249.

The apparent limitation of the range of *P. decussatum* to the basal portion of the section at the Grand rapids of the Saskatchewan, gives the species an especial interest from the stratigraphic standpoint. This, together with the extraordinary abundance of the shell in this horizon in the Saskatchewan River section, invites some further consideration of the variable characters of the species. In the numerous loose boulders of limestone in the old cut-off channel at Grand rapids and elsewhere in the vicinity this species is crowded together in such numbers that their separation except as fragmentary specimens is difficult. Other species are apt to be almost if not entirely excluded by this prolific shell from the beds containing it.

Dr. R. C. Wallace has recently found this shell at Hillbre and Fisher Branch, Manitoba. The collection sent the writer by Dr. Wallace appears to indicate its abundance at these localities which are more than 100 miles south of the Grand Rapids locality and near the base of the Silurian section.

The figures of this species, previously published, show what their authors consider typical specimens, but give little conception of the variability within its limits. Those which are here shown are intended primarily to illustrate the variable features of the shell.

Conchidium decussatum belongs to a group of shells in which the specific characters are very plastic. The rather large number of specimens of this species secured by the writer, show that plasticity or variability is as characteristic of this as it is of some of the other pentameroid shells. Most of the observations which have been made on the variability of this shell relate to the ventral valve because the collection contains very few dorsal valves, the great bulk of the specimens being ventral valves. Hence

the variable features which have been observed, relate chiefly to the contour of the shell, character of the striæ, and the spondylium in the ventral valve.

The ventral valve shows three well marked types of contour, viz. (1) Strongly convex with a more or less clearly defined median ridge extending from the umbonal region to the front of the shell. (2) Very convex with tumid umbonal region rounding regularly from the median region to the lateral and anterior margins without trace of median ridge. (3) Strongly convex in median and anterior region with or without median ridge, but with a broad shallow sinus extending from the beak across the umbonal region. These three types of contour make striking contrasts when individuals in which they are best developed are compared; but the intermediate forms in which neither the presence of ridge or sinus nor their entire absence can be positively stated, make difficult any attempt to discriminate them as distinct varieties. They might be conveniently designated as varieties a, b, and c of the species *C. decussatum* according as the fold is present or absent or the umbonal sinus is developed.

The radiating costae are generally best developed in the median region of the ventral valve, becoming much weaker or entirely obsolescent along the posterior half of the lateral margin of the valve. Fine concentric striæ cover the entire surface of the shell. In many specimens both in the dorsal and ventral valve, radiating striæ are obsolescent in the umbonal region except near the median line, the lateral striæ appearing anterior to the umbonal region and being most strongly developed near the front of the shell.

The collection contains a few small specimens which represent early ephibic stages of this species. They lack the gibbosity which characterizes the ventral valves of all gerontic individuals. An interesting feature of these immature shells is the nearly complete development of the spondylium which they show. One of the characteristic features of the species is the short spondylium, the length of which shows a ratio to that of the ventral valve usually of 1 to 5 or 6. In the small immature shells the ratio is 1 to 2.5 or 3. Thus it appears that the spondylium reaches approximate maturity at an early stage while the radiat-

ing plications attain their maximum strength and number only in the gerontic stage.

In the dorsal valve the septa are somewhat rudimentary in ordinary specimens and shorter than the spondylium. In one unique specimen, however, the septa of the dorsal valve are longer than the spondylium of the opposite valve and take an excentric course across the shell terminating near the middle of the left half of the valve (Plate IV, figure 4).

The maximum length in shells observed, is 3¼ inches.

Horizon and Locality.—Basal dolomite beds of section at Grand rapids, Saskatchewan river, Fisher branch and Hilbre, Manitoba. The specimens figured are all from Grand rapids.

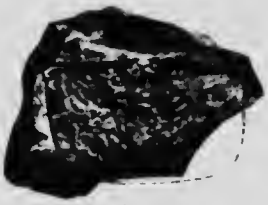
Explanation of Plate 1.

Leptaena sinuosus n.sp.

Figure 1. Natural cast of interior of ventral valve of type specimen x 2
" 2. Natural cast of exterior of ventral valve x 2. Figures 1 and 2 represent exterior and interior views of the same specimen of a ventral valve; Chemahawin, Man.
" 3. Natural cast of exterior of brachial valve x 2. Chemahawin, Man.
" 4. Natural cast of interior of dorsal valve x 2. Figures 3 and 4 represent exterior and interior casts of a single shell.

Leptaena parvula n.sp.

Figure 5. Natural cast of interior of ventral valve of type specimen x 2. West of Gypsumville, Man., 8 miles.
" 6. Gutta-percha cast of exterior of ventral valve x 2.
" 7. Natural cast of interior of dorsal valve x 2. Chemahawin, Man.
" 8. Natural cast of exterior of brachial valve. Chemahawin, Man.
" 9. Gutta-percha cast of interior of brachial valve x 2. West of Gypsumville, Man., 8 miles.



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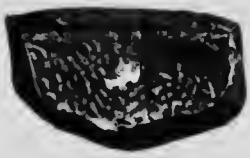

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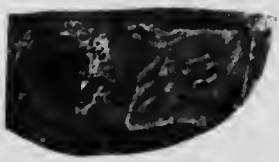

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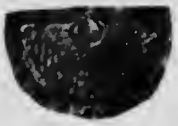

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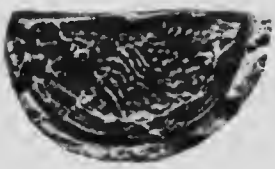

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Explanation of Plate II.

Conchidium decussatus Whiteaves.[1]

Figure 1-2. Dorsal view and cardinal profile view of the type specimens after Whiteaves.

" 3. Umbonal profile view of natural cast of ventral valve showing the angular fold characterizing variety a.

" 4. Umbonal profile view of ventral valve of a natural cast showing cavity of spondylium and median septum and the median ridge characterizing var. a, but less angular than in Figure 3.

" 5. Umbonal profile view of a partially exfoliated pedicle valve showing regularly rounded transverse outline characteristic of var. b.

" 6. Ventral view of a partially exfoliated pedicle valve showing shallow sinus characteristic of var. c.

[1] All figures in this and succeeding plates are natural size.

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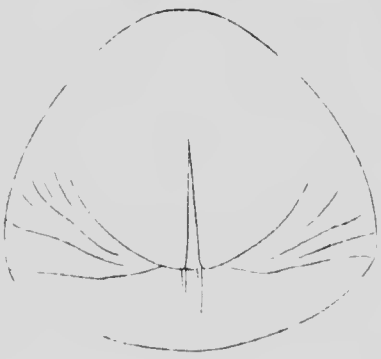

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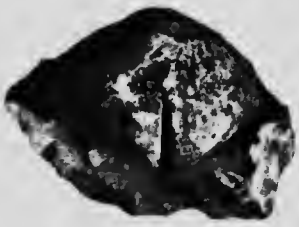

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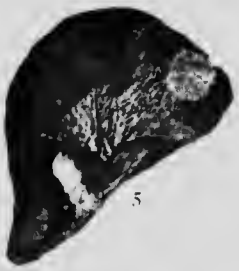

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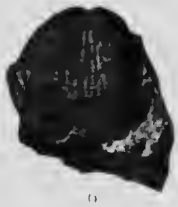

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Explanation of Plate III.

Conchidium decussatus Whiteaves.

Figure 1-3. Ventral, lateral profile and dorsal views of a partially exfoliated specimen of small size.

" 4. Ventral view of an exfoliated pedicle valve of a young individual showing the comparatively long median septum and very broad shell characterizing the ephippic stage of the species.

" 5. Dorsal view of an exfoliated fragmentary brachial valve of a young shell showing the comparative great breadth of the shell in early stages.

" 6. Lateral view of a pedicle valve showing the obsolescent character of the radiating plications in certain individuals. Note fine concentric striæ.

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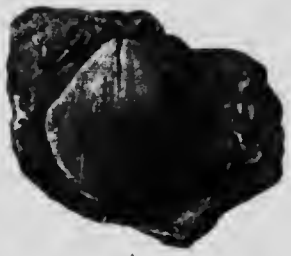

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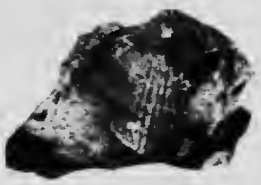

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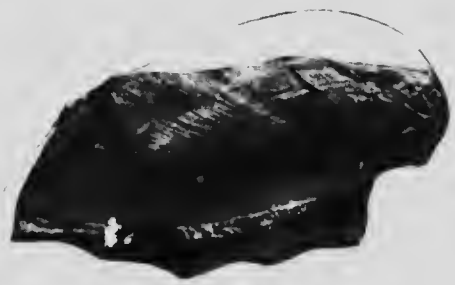

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Explanation of Plate IV.

Conchidium decussatus Whiteaves.

Figure 1. Dorsal view of an exfoliated brachial valve showing an abnormal lateral sinus and constriction in the margin of the shell and varices of growth.

" 2-4. Ventral lateral and dorsal views of a natural cast of an extremely gibbous form showing the angular median fold in each valve and the abnormal length and eccentric course of the septæ in the brachial valve.

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LIST OF MUSEUM BULLETINS.

The Museum Bulletins, published by the Geological Survey, are numbered consecutively and are given a series number in addition, thus: Geological Series No. 1, 2, 3, etc.; Biological Series No. 1, 2, 3, etc.; Anthropological Series No. 1, 2, 3, etc.

In the case of Bulletins 1 and 2, which contain articles on various subjects, each article has been assigned a separate series number.

The first Bulletin was entitled *Victoria Memorial Museum Bulletin;* subsequent issues have been called *Museum Bulletins.*

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Geol. Ser. 2. Note on Merocrinus, Walcott—by F. A. Bather.
Geol. Ser. 3. The occurrence of Holodont teeth at Ro : Miette and vicinity, Alberta—by L. M. Lambe.
Geol. Ser. 4. Notes on Cyclocystoides—by P. E. Raymond.
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Geol. Ser. 10. A new genus of dicotyledonous plant from the Tertiary of Kettle river, British Columbia—by W. J. Wilson.
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Geol. Ser. 16. The Pre-Cambrian (Beltian) of southeastern British Columbia and their correlation—by S. J. Schofield.
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